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TECHNICAL REPORT 9115

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THE RELATIONSHIP BETWEEN DOCTRINE FOR TACTICAL SMOKE USE AND  
EXPOSURE POTENTIAL: PRIORITIES FOR CONDUCTING SMOKE  
EXPOSURE ASSESSMENT STUDIES

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Frederick, MD 21702-5012



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## INTRODUCTION

### Background

Smoke exposure is inherently tied to the operational concepts and doctrine of the units which generate smoke. Theoretically at least, by understanding the U.S. Army smoke generating philosophy, a basic understanding of the conditions under which smoke exposure occurs can be obtained. The U.S. Army Medical Department (AMEDD) seeks to characterize exposure in order to determine potential dose of the smoke material to the soldier. Studies are underway to verify models which predict downwind dispersion of generated smoke and to measure airborne concentrations of smoke materials during actual field exercises. Because many different types of military units use a variety of equipment to generate smoke, characterizing exposure is potentially a long-term, logistically significant commitment. By evaluating doctrine and incorporating available knowledge on the duration and toxicity of the smoke material, a prioritization scheme can be developed which guides exposure assessment studies. This information also can be used by safety and AMEDD preventive medicine personnel to recommend when use of the protective mask is appropriate.

Throughout the modern battlefield, forces acquire and engage targets based on visual, infrared (IR), and millimeter wave technologies. Various forms of smokes and obscurants are used to deny the enemy observation and thereby enhance force effectiveness and reduce vulnerability to combat operations. U.S. forces will use obscurants whenever the tactical advantage to be gained outweighs potential degradation to friendly operations<sup>1</sup>.

U.S. forces use smoke to increase their effectiveness while reducing their vulnerability. Specifically, smoke will:

- a. Deny the enemy information
- b. Reduce the effectiveness of enemy target acquisition means
- c. Restrict nap-of-the-earth and contour approaches for enemy aircraft
- d. Disrupt organized enemy movement, operations, and command and control
- e. Create conditions to surprise the enemy
- f. Deceive the enemy<sup>2</sup>

Properly employed, smoke serves as a "combat multiplier;" that is, it provides an advantage without requiring additional combat resources. It denies the enemy critical targeting data while serving a simultaneous role in deception and economy of force missions. The ability to skillfully integrate the use of smoke is gained through training with smoke units that provide effective support<sup>3</sup>. It follows that units expecting to successfully complete

combat operations in reduced visibility will train in conditions which closely approximate those expected on the battlefield.

Because each level of command plans how to use smoke to support its overall tactical plan<sup>2</sup>, concepts documents discuss employment of smoke in general terms: the use of smoke is situation-dependent<sup>4</sup>. In any tactical operation the maneuver commander is solely responsible for all aspects of the planning and for the execution of the finalized plan. After selecting a strategy based on the results of his operations estimate, the commander will develop a plan focusing first on his scheme of maneuver then on those aspects of his plan which deal with "combat multipliers." Planning for smoke requires much imagination and initiative in the very early planning stages of any tactical operation<sup>5</sup>.

Consequently, soldiers will be exposed to smokes and obscurants in varying frequencies, durations, and concentrations depending on the tactical mission and the type of smoke mission being performed. In the Covering Force Area (CFA), for example, the troops are likely to encounter higher concentrations of smokes and obscurants for shorter periods of time. In the Main Battle Area (MBA) exposures are likely to be of higher concentration and medium duration. In the Rear Area (RA) lower concentrations but longer duration smoke/obscurant exposures are likely to be encountered.

#### U.S. Smoke Producing Capabilities

Obscured environments are produced through the use of pyrotechnics (hand grenades and smoke pots), projected munitions (both mortar and artillery), vehicular defense systems (grenades and vehicle exhaust systems), and chemical units with smoke generators. U.S. smoke materials currently in use include fog oil, diesel fuel, hexachloroethane (HC), white phosphorus (WP), red phosphorus (RP), brass particles, and colored dyes. A list of the various U.S. Army smoke producing means<sup>6</sup> is found in Appendix A.

#### Health Hazard Considerations

Just as the tactical purposes for which smoke is used and the material used to create the cloud vary, health hazards vary with the material and the frequency, duration, and concentration of exposure. There are potential health implications, some being of a serious nature, involved with the use of smoke/obscurants in training and in combat. Long-term, the use of a smoke/obscurant with toxic constituents may create chronic health problems for exposed soldiers. Estimated field concentrations are in the range where adverse effects such as nonreversible lung damage have been found in laboratory animal studies<sup>7</sup>; and it is possible that similar effects will occur in humans. Short-term, smoke/obscurants may temporarily incapacitate soldiers creating an advantage for the enemy. The incapacitation may take the form of a reduction in physical performance due to irritation of eyes and respiratory tract<sup>8</sup> or to an extreme anxiety and disorientation in soldiers operating in an obscured unknown environment. Current training policy (Appendix B) requires wearing protective masks in certain smoke environments which may, in the case of driving an armored vehicle for example, create a safety problem.

## Previous Health Related Research

In the past, research into the health effects associated with exposure to chemical smokes and obscurants has centered on toxicologic studies on the principal smoke materials, fog oil, and HC. Increasing use of high technology in weapon systems has prompted development of more effective smokes and obscurants. The addition of infrared-defeating components is an example of modifications being made to filler materials. As a result of improvements to existing smoke munitions and the development of new materials, the chemical and physical characteristics of the smokes have changed. Toxic effects of various smoke materials in the inventory have been studied, and medical research on smokes and obscurants under development is ongoing. The U.S. Army Biomedical Research and Development Laboratory (USABRDL), in conjunction with the U.S. Army Materiel Command Project Manager for Smoke/Obscurants (PM SMOKE) and the U.S. Army Chemical Research, Development and Engineering Center (CRDEC), has been evaluating the potential health effects of inventory, product improved, and developmental smoke/obscurants. Health effects and toxicology studies are done on the materials using various animal species. Such studies identify effects which could result in decrements in performance as well as diminished health for the soldier. The technical approach has been to identify data gaps through literature searches and problem definition studies, and then to initiate appropriate genotoxicity, inhalation, dermal, eye, and oral studies. The data generated by this research are used by independent medical evaluators in the assessment of system health hazards and the preparation of health hazard assessment reports.

## Need for Exposure Assessment

While animal data serve a useful purpose, they must be supplemented with exposure data to assess risk properly<sup>9</sup>. The weakest link in our understanding of the relation of hazard identification studies to field exposures is our lack of knowledge of the conditions of human exposure to smoke and obscurants. Little effort has been placed on qualitatively assessing or quantitatively measuring actual exposures experienced by soldiers. Following adoption of Army Regulation 40-10, which initiated the health hazard assessment program, the Office of The Surgeon General (OTSG) developed a list of health hazard assessment program research priorities<sup>10</sup> which includes quantification of exposures to screening smoke and obscurants. Screening smoke is employed within areas of friendly operation, or in areas between friendly and enemy forces, to degrade enemy ground and aerial observation and fire. It is intended primarily to conceal friendly forces and usually requires large quantities of smoke for long periods<sup>11</sup>. A letter summarizing the health risks due to exposure to smoke/obscurants<sup>12</sup> stated that the "intensity and duration of troop exposure to smoke" and "the demographics of the troops being exposed" are unknown. These gaps in information have impacted heavily on the development of a realistic smoke masking policy. An earlier assessment by USABRDL in support of an OTSG effort to formulate masking policy estimated potential exposures by using Army Test and Evaluation Program (ARTEP) tasks to estimate the amount of smoke use, but none of the tasks included operations with fog oil, the most widely used screening smoke<sup>12</sup>.



An in-depth review of Army field manuals, school course materials, and other doctrinal publications was conducted in order to determine if a relationship existed between doctrine and either duration or frequency of smoke exposure. The best examples of the type of information available is illustrated in Appendix C. Field manuals lack enough detailed instruction on the employment of smoke to serve as a basis for exposure research plans, even in cases where examples are given. It is generally stated in field manuals that troops involved in combat operations will be exposed to smoke (Appendix C). There are some school course materials<sup>13</sup> which are more detailed, but others, like Command and General Staff College Reference Book 100-35, Tactical Reference Data<sup>14</sup>, do not even discuss smoke assets available to maneuver units. Additionally, an increasing awareness of the value and availability of smoke on the part of the combat and combat support branches is developing<sup>15</sup> and current concepts<sup>1,3</sup> include the use of smoke in rear areas. Consequently, almost everyone on the battlefield can expect to be exposed to some quantity of smoke at least some of the time. One very generalized estimate postulates durations as follows: for 60 percent of the time exposures will be less than 2 hours; 70 percent of the time, <4 hours; 80 percent of the time, <6 hours; and 99 percent of the time, <8 hours<sup>12</sup>. The doctrinal information proved to be too general and was insufficient for the purpose of determining either duration or frequency of exposure, or as might be used to rank the exposures of the various smokes. Following the doctrinal literature review, discussions were held with concepts and doctrine personnel and with training personnel in the U.S. Army Training and Doctrine Command, all of whom are responsible for defining or teaching tactical smoke use. These discussions were followed up with additional conversations with field unit commanders and senior noncommissioned officers. While the interview provided valuable insights into the relationship between doctrine and situation-specific factors (e.g., meteorology), they were still not adequate to define goals or priorities for smoke exposure assessment research.

An approach was subsequently developed which integrated information learned from observing actual smoke training, the review of doctrinal information and prior staff experience with exposure and hazard assessment.

#### APPROACH

The objective is to determine the health hazards of exposures to smoke and obscurants encountered by troops in the course of performing their normal duties. Achieving this objective includes the following subobjectives:

- a. Identify those populations likely to be exposed to smoke and obscurants.
- b. Evaluate exposure parameters and smoke toxicity in order to define research priorities and efforts.
- c. Conduct field studies to quantify exposures.
- d. Periodically review the plan and add or delete potentially exposed populations, materials, and methods of delivery as changes occur. Adjust the sampling priority list accordingly.

## RESEARCH PLAN

### Task 1

Research objective: Determine those soldiers who, by virtue of their military occupational speciality (MOS) or duty location, are most likely to encounter smoke and obscurants.

Research justification: Information on the characteristics of soldier populations (medical demographics) is a part of the total data base needed to establish acceptable exposure levels for the population of interest. The medical demographics required fall into two major categories: biological factors which influence exposure levels (e.g., health status, eating habits, and behavioral characteristics) and biologic factors which influence toxicity (e.g., age, sex, and genetic factors). From an understanding of the biologic factors which influence pollutant toxicity, partial understanding of dose response is obtained. Physical/chemical factors affecting toxicity and animal toxicity data (extrapolated to humans) are combined to establish the final estimated dose response of the target population to a specific population. In some cases the level of exposure for a particular MOS may be of interest. Chemical Operations Specialist (54B10) is one such example, particularly since this MOS offers advancement through the enlisted grades to Sergeant Major. Consequently, chemical soldiers may continue to be exposed to smoke throughout their entire career. In other cases, the field duty location may warrant study. A forward airfield or a division tactical operations center operated under a haze would have a wide variety of MOSs represented but no single MOS would have a population sufficient to study individually.

Implementation: Information as to the specific use of smoke munitions will be obtained from branch schools and using units and evaluated in terms of research potential (number of exercises annually, number and type of smoke material(s) to be used, number of soldiers exposed, etc.). Conclusions on the general applicability of the smoke use as it relates to doctrinal principles will be confirmed by interviewing subject matter experts prior to designing specific exposure sampling plans.

### Task 2

Research objective: Establish an order of priority for sampling.

Research justification: As a result of multiple variables associated with exposures, the large number of personnel potentially exposed both by MOS and by duty location, and limited research manpower and fiscal resources, sampling efforts need to be prioritized.

Implementation:

a. Exposure ranking - Unitless values for the expected frequency and duration of each type of smoke use and an estimate of the concentration of the smoke (haze, fog, etc.) with one being low and three being high will be assigned based on the published concepts (Appendix D) and user information obtained. Adding the assigned values will produce an exposure score. A

soldier who infrequently experienced a medium concentration of smoke over periods of medium duration would have an exposure score of 5 assigned by an industrial hygienist (Table 1).

**Table 1. Likelihood of Exposure (example)**

LOW = 1	MEDIUM = 2	HIGH = 3
FREQUENCY		1
DURATION		2
CONCENTRATION		2
EXPOSURE SCORE =		5

b. Toxicity ranking - The next computation in prioritization is for a subject matter expert (toxicologist) to factor in a toxicity value from a five point scale based on studies done with the smoke/obscurant materials. The toxicity of materials ranges from the most toxic (5) to the least toxic (1) (Appendix E) with the other materials ranked between them. The sampling priority score would then be determined by multiplying the two numbers together and adding one additional point if the material has been shown to mutagenic or to cause cancer in animals or humans (Table 2). The worst case scenario would have an exposure score of 9 multiplied by a toxicity factor of 5 plus a positive mutagenicity point for a priority score of 46.

**Table 2. Sampling Priority (example)**

EXPOSURE	x	TOXICITY	+	MUTAGENICITY	=	PRIORITY SCORE
9	x	5	+	1	=	46

c. Smoke hazard ranking - The next step in establishing priority for sampling involves ranking the priority scores as determined above from highest to lowest with the highest value having the highest priority. Once the list (Appendix F) has been established, administrative decisions as to how best to conduct the research can be made. For example, it may be that the highest priority circumstance has been prohibited for safety reasons or environmental concerns or a large-scale field exercise including a lower priority number scenario may occur when sampling resources are available.

### Task 3

**Research objective:** Following the priority rankings established in Appendix F, conduct field sampling during normal training activities to quantify actual exposures.

**Research justification:** To develop prudent occupational exposure criteria, there must be adequate field exposure data as well as adequate toxicology data. The current masking policy (Appendix B) is conservative in that it provides for a high degree of respiratory protection in all exposure circumstances. Masking in the situations listed in the policy has been deemed necessary as a result of health effects observed after exposure incidents but without the benefits of scientifically derived exposure data. If concentrations measured during field exposures were within ranges shown to have minimal effects, exposure criteria appropriate for the circumstances could be established. As a result, alternatives to masking could be provided.

**Implementation:** Smoke and obscurant materials will be sampled using standard, noninvasive industrial hygiene methods modified to be consistent with military operations and the specific characteristics of the smoke materials to be sampled. This research has been classified as less than minimal risk<sup>16</sup> since subjects and nonsubjects will be exposed to normal working conditions. Approval for routine use of human subjects has been obtained. Selection of populations to be studied will be based on the sampling priority numbers and practical considerations such as availability of troops and munitions. Since the intent is to measure actual occupational exposures, sampling will occur during normal training exercises with no attempt to influence the activities being conducted. Gaining the cooperation of smoke users requires considerable education as to the purposes and mechanics of the sampling which is to be done. As a result, field studies must be closely coordinated with units and schools, and commands and installations following clearance for the research through appropriate command channels. Technical reports produced as a result of the studies will be provided through command channels to the units/schools involved.

### Task 4

**Research objective:** Conduct periodic reviews of exposure scenarios and toxicity information to update sampling priority numbers.

**Research justification:** Tactical training exercises and medical research budgets are being tightly constrained as defense funding is reduced thereby necessitating careful scrutiny of research opportunities. As doctrinal changes occur, new smoke and obscurant materials are fielded, and the toxicological data base expands, shifting of sampling priorities may be required.

**Implementation:** Close liaison with the doctrine and development communities will be maintained. A frequent update of the sampling priority list should be accomplished by recomputing priority scores to incorporate changes in materiel status and doctrine, and newly developed toxicity data.

## SUMMARY

As highly sophisticated target acquisition means are developed, use of countermeasures in the form of smokes and obscurants become critical to success on the battlefield. Materials used to defeat electronic and visual systems have been shown to cause varying degrees of health effects in animals and man. In order to properly assess the overall risk to soldiers, a realistic measure of actual exposure to obscurant materials must be made.

Doctrinal and training literature do not provide sufficient information to characterize either smoke frequency or duration. This document describes a four-point research plan developed to derive the exposure data critical to establishment of occupational exposure criteria. Military populations should be characterized on the basis of exposure frequency and duration, based upon job classification and work assignments. Following identification of potentially exposed populations, field sampling will be prioritized based on the likelihood of exposure and the toxicity of the material. Field sampling will be done using generally accepted industrial hygiene methods to quantify the actual exposures soldiers are experiencing. Since new materials are being fielded and doctrinal uses change, periodic review of the sampling priority list will be accomplished. Data resulting from sampling will be incorporated into exposure criteria for the various smoke and obscurant materials.

The relative priority ranking assigns the highest priority for exposure potential to military operations on urbanized terrain (MOUT) training with HC and colored smokes. The large number of reported deaths and injuries associated with HC in MOUT training is well documented and consistent with the ranking assigned. Similar reports for colored smoke have not surfaced although the use of these smokes for this purpose appears to be recent. With the U.S. Army increasing emphasis on MOUT training, similar emphasis on assessing exposure to colored smoke also appears to be appropriate. Other training uses of HC deserve exposure characterization due to the high toxicity of this material. The rankings also would suggest that smoke exposure to armored vehicle crewmen be addressed.

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## APPENDIX A

### LISTING OF UNCLASSIFIED U.S. ARMY SMOKE AND OBSCURANT MUNITIONS

#### I. GENERATED SMOKE

##### A. Hand Grenades

M8 (HC) Smoke Grenade  
M15 WP Smoke Grenade  
M18 (Green, Red,  
Violet, Yellow)  
M48 Red Smoke  
M185 Personnel distress  
Red  
M186 Personnel distress  
Colored

##### B. Smoke Pots

M1 HC Ground Smoke Pot  
M4A2 HC Floating Smoke  
Pot  
M5 HC Ground Smoke Pot  
AN-M7A1 Floating Fog  
Oil Smoke Pot

##### C. Generators

M3A4 Smoke Generator  
M157 Mobile Smoke  
Generator Set  
M1059 Smoke Carrier

#### II. PROJECTED SMOKE

##### A. Long Range

M60 Series 105 mm WP  
M84 Series 105 mm HC &  
Colored  
M110 Series 155 mm WP  
M116 Series 155 mm HC &  
Colored  
M825 155 mm WP

##### B. Medium Range

- Rockets  
M259 (2.75" WP)  
M156 (2.75" WP)  
  
- Projectiles (Guns)  
M308 Series 57 mm WP  
M311 Series 75 mm WP  
M361 Series 76 mm WP\*  
M313 Series 90 mm WP\*  
M416 Series 105 mm WP  
M357 Series 120 mm WP\*  
  
- Mortar Rounds  
M302 Series 60 mm WP  
M57 Series 81 mm WP  
M370 Series 81 mm WP  
M375 Series 81 mm WP  
M2 Series 4.2" WP or  
PWP  
M328 Series 4.2" WP

##### C. Short Range

- Grenades  
M680 40 mm White,  
Canopy  
M676 40 mm Yellow,  
Canopy  
M682 40 mm Red, Canopy  
M713 40 mm Red, Ground  
Marker  
M715 40 mm Green,  
Ground Marker  
M716 40 mm Yellow,  
Ground Marker

\* - not currently  
maintained in the inventory



### III. SELF-DEFENSE SYSTEMS

#### A. Vehicle

- Vehicle Engine Exhaust Smoke Systems (VEESS)

M1 & M60 Tanks

M88

AVLB

M2/M3 Infantry Fighting Vehicle

- Launched Grenades

L8A1/L8A3 RP Grenade System

M76 IR Smoke Grenade

#### B. Perimeter

M1 HC Ground Smoke Pot

M4A2 HC Floating Smoke Pot

M5 HC Ground Smoke Pot

AN-M7A1 Floating Fog

Oil Smoke Pot

M3A4 Smoke Generator

M157 Mobile Smoke

Generator Set

M1059 Smoke Carrier

**APPENDIX B**  
**U.S. ARMY SMOKE MASKING POLICY**

ROUTINE  
R 101632Z DEC 85  
FM CDR AMCCOM ROCK ISL IL //AMSMC-SFS//  
TO AIG 7427  
INFO DA WASHDC //DASG-PSP//  
COR USAEHA APG MD //HSHB-01//  
P 272030Z NOV 85  
FM DA WASHDC //DAPE-HR//  
TO AIG 7406  
PMSMOKE APG MD //AMCPM-SMK//  
COR TRADOC FT MONROE VA //ATEN-S/ATCO-NC//  
COMDT USA CMLSCH FT MCCLELLAN AL //ATZN-CM-C//

ZYUW RUCIAFB7677 3441644  
AIG 7428  
CDR AMC ALEX VA //AMCSG-1//  
AIG 7446

UNCLAS

MG ECKELBARGER, DIRECTOR OF ARMY SAFETY, SENDS

TWO PART MESSAGE

SUBJECT: SMOKE SAFETY

- A. MSG, DAMO-SSC, 281255Z JUL 78, SAB.
- B. MSG, DAMO-SSC, 052005Z SEP 78, SAB.
- C. MSG, DAMO-NCC, 071225Z SEP 79, SUBJ: SAFETY CONSIDERATIONS FOR USE OF HC SMOKE DURING TRAINING.
- D. MSG, DAMO-NCC, 211549Z FEB 80, SUBJ: EXPOSURE OF FEMALES TO SMOKES, PEG 200 AND CS.
- E. AR 385-63, POLICIES AND PROCEDURES FOR FIRING AMMUNITION FOR TRAINING, TARGET PRACTICE AND COMBAT, 15 OCT 83.

PART ONE FOR ALL

1. DURING A RECENT TRAINING EXERCISE, 22 SOLDIERS WERE OVERCOME BY SMOKE FROM AN AN-M8 HC SMOKE GRENADE. THE OCCURRENCE OF THIS INCIDENT, AND OTHER SIMILAR INCIDENTS, INDICATE THE NEED FOR REEMPHASIS OF DA SAFETY POLICY REGARDING TRAINING IN SMOKE. THE FOLLOWING PRECAUTIONS, RESTATED FROM REFERENCED MESSAGES, APPLY TO ALL SMOKE TRAINING, INCLUDING HC, WP, PWP, FOG OIL, RED PHOSPHORUS (RP), COLORED SMOKE, AND DIESEL SMOKE:

A. PERSONNEL WILL CARRY THE PROTECTIVE MASK WHEN PARTICIPATING IN EXERCISES WHICH INCLUDE THE USE OF SMOKE.

B. PERSONNEL WILL MASK:

(1) BEFORE EXPOSURE TO ANY CONCENTRATION OF SMOKE PRODUCED BY M8 WHITE SMOKE GRENADES OR SMOKE POTS (HC SMOKE) OR METALLIC POWDER OBSCURANTS.

(2) WHEN PASSING THROUGH OR OPERATING IN DENSE (VISIBILITY LESS THAN 50 METERS) SMOKE SUCH AS SMOKE BLANKETS AND SMOKE CURTAINS.

(3) WHEN OPERATING IN OR PASSING THROUGH A SMOKE HAZE (VISIBILITY GREATER THAN 50 METERS) AND THE DURATION OF EXPOSURE WILL EXCEED FOUR (4) HOURS.

(4) ANYTIME EXPOSURE TO SMOKE PRODUCES BREATHING DIFFICULTY, EYE IRRITATION OR DISCOMFORT. SUCH EFFECTS IN ONE INDIVIDUAL WILL SERVE AS A SIGNAL FOR ALL SIMILARLY EXPOSED PERSONNEL TO MASK.

(5) PERSONNEL WILL MASK WHEN USING SMOKE DURING MILITARY OPERATIONS IN URBAN TERRAIN (MOUT) TRAINING WHEN OPERATING IN ENCLOSED SPACES. NOTE: THE PROTECTIVE MASK IS NOT EFFECTIVE IN OXYGEN DEFICIENT ATMOSPHERES. CARE MUST BE TAKEN NOT TO ENTER CONFINED SPACES WHERE OXYGEN MAY HAVE BEEN DISPLACED.

(6) SMOKE GENERATOR PERSONNEL WILL MASK WHEN IT IS IMPOSSIBLE TO STAY UPWIND OF THE SMOKE.

2. SHOWERING AND THE LAUNDERING OF CLOTHING FOLLOWING EXERCISES WILL ELIMINATE THE RISK OF SKIN IRRITATION FOLLOWING EXPOSURE TO SMOKE. TROOPS EXPOSED TO SMOKE SHOULD REDUCE SKIN EXPOSURE BY ROLLING DOWN SLEEVES.

3. SPECIAL CARE MUST BE TAKEN WHEN USING HC SMOKE TO ENSURE THAT APPROPRIATE PROTECTION IS PROVIDED TO ALL PERSONNEL WHO ARE LIKELY TO BE EXPOSED. WHEN PLANNING FOR THE USE OF HC SMOKE IN TRAINING, SPECIFIC CONSIDERATION MUST BE GIVEN TO WEATHER CONDITIONS AND THE

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POTENTIAL DOWNWIND EFFECTS OF THE SMOKE. POSITIVE CONTROLS, (OBSERVATION, CONTROL POINTS, COMMUNICATIONS) MUST BE ESTABLISHED TO PREVENT EXPOSURE OF UNPROTECTED PERSONNEL.

4. REQUEST APPLICABLE PUBLICATIONS AND STANDING OPERATING PROCEDURES BE REVIEWED TO ENSURE APPROPRIATE SAFETY PRECAUTIONS FOR USE OF SMOKE ARE INCLUDED IN TRAINING AND EMPLOYMENT GUIDANCE. COMMANDERS SHOULD ENSURE THIS POLICY IS WIDELY DISSEMINATED.

PART TWO FOR TRADOC

5. REQUEST THAT AR 385-63 (CHAPTER 17) AND APPLICABLE FIELD MANUALS BE REVISED AS SOON AS POSSIBLE TO CLEARLY STATE THIS SMOKE SAFETY POLICY. BT

**APPENDIX C**  
**SMOKE EMPLOYMENT GUIDANCE**

**Field Circulars (FC)**

3-50-1                      Deliberate Smoke Operations

**Field Manuals (FM)**

5-100	Engineer Combat Operations
6-20	Fire Support in Combined Arms Operations
6-30	Observed Fire Procedures
6-121	Field Artillery Target Acquisition
7-10 (HTF)	Infantry Company (IN, AB, AA and R)
7-20	The Infantry Battalion (IN, AB, AA and R)
7-30 (HTF)	Infantry, Airborne, Assault Brigade Operations
30-5	Combat Intelligence
31-71	Northern Operations
71-1	Tank and Mechanized Infantry Company Team
71-2	Tank and Mechanized Infantry Battalion Task Force
71-3	Armor and Mechanized Infantry Brigade Operations
71-100	Armor and Mechanized Infantry Division Operations
71-101	Infantry, Airborne, Air Assault Division Operations
90-2	Tactical Deception
90-3	Desert Operations
90-4	Air Mobile Operations
90-5	Jungle Operations
90-6	Mountain Operations
90-10	Military Operations on Urbanized Terrain
90-13	River Crossing Operations
90-14	Rear Battle
100-5	Operations

**TRADOC Pamphlet**

525-3                      Operational Concepts for Smoke and Obscurant Employment  
and Countermeasures

## Extracts of Typical Smoke Employment Guidance

### 1. Division Operations. FM 71-101, Infantry, Airborne, and Air Assault Division Operations, 26 March 1980.

a. Discusses the Division as a self-sustaining force capable of independent operations for a long period of time.

b. Smoke operations are only mentioned in the sections dealing with the Infantry Division, no smoke mentioned in the sections pertaining to Airborne or Air Assault Division.

c. Page 4-16: During offensive operations, smoke delivered by field artillery and mortars is used to degrade enemy observation. Obscuration smoke is used to place near enemy position to hinder their observation. Concealing smoke is placed between friendly troops and the enemy. Smoke also is used to deceive the enemy. Troops are cautioned about the silhouette effect should they advance beyond the smoke screen. In this case, they should find natural cover and concealment.

d. Page 5-15: During defensive operations, smoke is placed near the enemy to obscure their over watch. Obscuration is used to separate enemy first and second echelon forces so that the Division can engage the first echelon force. Smoke also is used for disengagement and to conceal troop movement out of the area.

e. No mention of Division organic chemical assets in terms of chemical units or types of smoke material to use.

### 2. Air mobile operations. FM 90-4, Air Mobile Operations, 8 October 1980. The only mention of the use of smoke is on page C-35, where it lists the use of colored smoke for marking landing zones.

### 3. MOUT Operations. FM 90-10, Military Operations on Urbanized Terrain (MOUT), 15 August 1979.

a. Tactical doctrine stresses that urban combat operations are to be conducted only when required, and that built-up areas are to be isolated or bypassed because MOUT is rather costly and time-consuming.

b. Pages 2-9 and 2-11: Enemy-owned and defended strip areas are not easily bypassed; therefore, they may have to be attacked. Attack of a strip area involves SUPPRESS, OBSCURE, and PENETRATE. Extensive use of smoke may be required to conceal troop movements. The type of smoke to be used is not specified. The intensity of close combat requires continued suppressive fires and smoke.

c. Pages 2-31 and 2-37: The maximum use of smoke will cover advances in towns. The advance should proceed quickly because of troop movement signatures. Smoke cover is used up to the point where the lead attack element has closed to within 500 meters of enemy positions. Smoke is then shifted and maintained no more than 500 meters ahead of lead elements as they advance. To

summarize, maneuver over approaches to a built-up area must be obscured by smoke and protected by over watching fires.

d. Page 3-1: The enemy may exploit the use of smoke in conjunction with darkness and limited visibility conditions to conceal their movement.

e. Page 3-5: The enemy's deliberate attack may be preceded by artillery bombardment of our positions, using smoke as one of the means to suppress while they negotiate obstacles on their approaches. Smoke use may continue immediately before the assault when the engineers move forward under smoke to neutralize barriers and breach minefields.

f. Pages 4-2 and 4-3: Our field artillery may use smoke (unspecified), along with HE, fuze VT and Time to engage roof tops and upper story windows to prevent enemy observation. Shell smoke is used, but troops should not rely on this as cover.

g. Page 4-8: Smoke generator units may be used for both offensive and defensive MOUT operations. During offensive, smoke supports maneuver and deception; in defensive, it limits enemy observation and target acquisition. Smoke pots, generators, or artillery smoke munitions are used to cover withdrawing defensive forces. Artillery-delivered WP is used on the enemy to inflict casualties and fires. M203 launched grenades can be used to mark targets for helicopter attack.

h. Page B-4: The M203 40-mm Grenade Launcher can be used to suppress heavy weapons and antitank gunners and to disable enemy armored vehicles when other antitank weapons are not available.

i. Page B-5: The M34 WP Smoke (Hand) Grenade, can be used for destroying flammable objects, to drive the enemy out of wooden structures, and to create smoke screens to conceal movement. M8 HC White Smoke and M18 Colored Smoke Grenades, can be used to screen small squad or individual movements, to supplement screening provided by artillery, mortars, or smoke pots and to mark locations or provide visual signals.

#### 4. River Crossing Operations. FM 90-13 River Crossing Operations, 1 November 1978.

a. Defines tactics and techniques for river crossing operations in both offense and retrograde.

b. Page 1-10: Smoke is cited as one of the considerations for deception of enemy during retrograde.

c. Page 3-21: During offensive crossings, lead battalions secure immediate areas around entry points and begin suppressing enemy direct fire. The areas need not be large, and suppressing all enemy fires is not necessary. Darkness and smoke can provide obscuration.

d. Pages 5-13 through 5-15: The general benefits of smoke in river crossings are discussed. Smoke is used for concealment and deception. Use of smoke at night is preferred.

e. The sample OPLAN/OPORD did not address use of smoke.

5. Mountain Operations. FM 90-6, Mountain Operations, 30 June 1980. No mention of the use of smoke.



## APPENDIX D

### EXPOSURE RANKING

#### Smoke Exposure Conditions and Research Priority Ranking

##### 1. Introduction.

a. The expected frequency and duration of personnel exposure to smoke, and the concentration levels to which exposure occurs are the criteria used in establishing the exposure severity ranking. For simplicity, each criterion for a smoke exposure condition is subjectively evaluated and is given a ranking of high, medium, or low with the corresponding ranking values of 3, 2, and 1 assigned. Severity of the exposure conditions is the sum of the assigned numbers of the three criteria.

b. The concentration levels of smoke in outdoor situations may fluctuate, depending on the adiabatic conditions, terrain, and wind speed and directions. Regarding the estimation of exposure concentration levels, assumptions are made that there is minimal vertical mixing and low wind speed, i.e., minimum disturbance of the smoke cloud.

c. The following discussion outlines those smoke materials currently in the Army inventory; and the assumptions and rationale made regarding the severity of exposure based on the frequency, duration, and concentration levels of the smoke. Smoke exposure situations as described are largely based on information gathered from the field over the past 3 years. The authors have reviewed the collected information and as a result, made some subjective evaluation of each exposure condition. There may be inconsistencies in the interpretation between how smoke should be used (doctrine) and how smoke is used (reality). To this end, we invite the readers to critically review the information below and to submit comments to the Commander, U.S. Army Biomedical Research and Development Laboratory, ATTN: Health Effects Research Division (SGRD-UBG), Fort Detrick, Frederick, MD 21702-5010, commercial telephone (301) 619-7207 to DSN 343-7207.

##### 2. Smoke exposure conditions and ranking.

a. Fog oil smoke is a general purpose smoke, primarily used to generate large area smoke screens. Fog oil generator operators assigned to a chemical unit are trained and responsible to produce the smoke. Normally, generator operators mount the M3A4 generators on a jeep and trailer, or on a high mobility, multipurpose wheeled vehicle (HMMWV), move to a mission site, and receive orders to generate smoke. Smoke can be generated at a stationary position or while the vehicle is in motion. A newer smoke generator system also is available. This new system is called either the M157 that is mounted on a HMMWV or the M1059 that is mounted on the M113 Armored Personnel Carrier (APC). The new system is an improved version of the M3A4 with automated controls and flow release mechanisms. Operators on the HMMWV with the M157 or inside the M113 APC with the M1059 produce the smoke while the vehicle moves. Fog oil smoke is intended to deliberately cover friendly forces. Because of the time it takes to start and stabilize the smoke operation, the usage is

most suitable in the communications zone and the rear area. Use of fog oil smoke in the combat zone or the front edge of battle area is generally an unusual event. As a matter of precaution to provide adequate protection for the smoke generators and operators, initial start-up may involve the use of HC smoke, for instantaneous coverage of the generator positions. Hexachloroethane smoke is discussed in the paragraph 2b below. In most training situations, HC smoke is not used with fog oil. In combat, the concealment of personnel and the smoke generator becomes so critical that the HC smoke is expected to be used during the fog oil generator start-up.

(1) The generator operators, whether on a jeep, trailer, HMMWV, or in an APC, are exposed to fog oil smoke. In peacetime, training often involves the use of fog oil smoke. Occasionally, diesel fuel may be added to fog oil at a ratio of 1:1 to conserve fog oil. However, in 3 years of information gathering from training events, the mixing of diesel fuel and fog oil has not been encountered. The frequency of exposure for fog oil smoke generator is considered to be high [3]. Fog oil smoke is supplied from a 55-gallon container, the content of which normally lasts from 50 minutes to 90 minutes. Durations of exposure in training situations are governed by the rate of consuming one 55-gallon container. Longer periods of smoke generation are possible, but not frequent. The duration of exposure is considered to be medium with a ranking of 2. Generator operators perceive fog oil smoke as being quite safe to use. The operators normally locate themselves upwind of the generator during stationary operations. Sudden wind changes may occur and bring the smoke cloud over the operators. Operators tend to remain in the cloud. In mobile smoke operations using either the HMMWV or the APC with the fog oil generators, operators can be exposed to fog oil smoke. Fog oil smoke can find its way into the crew compartment during normal operation. If the APC moves into the fog oil smoke cloud, more smoke in the compartment can be expected. The dissipation of fog oil smoke concentration in the crew compartment largely depends on the available ventilation. Operators do not like to drive the vehicles into smoke because of visibility problems. They may still be exposed to fog oil smoke as a result of driving along the edge of the cloud. In any event, the operators are most likely exposed to high concentration levels inside the APC. The ranking of the 3 is given to the severity of concentration levels of exposure received by the generator operators. The total exposure ranking score for fog oil smoke generator operator is 8.

(2) Fog oil smoke is delivered to deliberately cover military operations. Troop populations operating in the fog oil smoke may include operating forces (both friendly and opposing forces), combat support element personnel, and combat service support element personnel. In practice, fog oil smoke is used in large-scale training exercises in which smoke missions are introduced into the combat scenario involving a chemical unit. (Small size units such as squad and even platoon size units do not usually request fog oil smoke support because of the planning involved. Squad leaders find HC smoke or colored smoke more expedient.) The frequency of exposure for the ground troops is considered medium [2]. The duration may be long [3]. The concentration levels must be high in order to produce sufficient obscuration but probably lower than those experienced by the generator operators. In terms of concentration, the exposure rating of medium [2] is therefore given.

The total score of severity of exposure for ground troops working in fog oil smoke is 7.

b. Hexachloroethane smoke for our own troops and friendly forces is available in two forms: the M5 smoke pots and the M8 smoke grenade. The HC smoke can be delivered in 155mm artillery rounds into enemy territories to slow and delay enemy movements. Friendly troops are not normally exposed to artillery delivered HC smoke. The M5 smoke pot finds its use for instantaneous coverage of the fog oil generator at the beginning of fog oil smoke operations. In training practice, HC smoke has not been used to supplement the fog oil smoke generators. In combat, M5 HC smoke pots can be used in delay operations, short-term defense of an urban area, deliberate and hasty airborne infantry assault attack, air mobile assault, and combat engineer operations. The M5 HC smoke pots can be dropped off a retreating vehicle to create screens. One M5 pot lasts from 18 to 22 minutes. The M8 HC grenade, is generally used as a field expedient smoke where fog oil smoke support from a chemical unit is not readily available. An M8 HC grenade would last from 5 to 8 minutes. The release of HC smoke from both the M5 and the M8 devices is rapid and profuse. The instructors at the U.S. Army Chemical School (USACMLSCH) have been instructing the students on the application of HC smoke with a demonstration of its use. Students are warned of the potential hazard of HC smoke, the rapidity of the smoke generation, and the precautionary measures necessary to prevent exposure. Infantry soldiers do regularly use the M8 smoke grenades in MOUT training. Other personnel may use HC for various training activities. Occasionally, HC smoke grenades are used in the obstacle courses for testing of candidates qualifying for the requirements of the Expert Infantry Badge (EIB) or the Expert Field Medical Badge (EFMB). The HC smoke also may be used in buildings where firefighters conduct their annual training designed to develop/practice their rescue skills in smoke.

(1) Instructors at the USACMLSCH often use HC smoke for the "Employ and Ignite Demonstration" training of the 54B10 students. The M5 HC smoke pots are normally used. Frequency of HC use for the instructors is medium [2], and the students are present on a one-time basis. Duration of exposure is short [1]. Concentration levels of HC is high, but instructors and students normally stay upwind of the smoke. As a result, the concentration levels to which the instructors and the students are exposed are minimal [1]. The total score of HC exposure in the USACMLSCH is 4.

(2) Infantry soldiers normally use the M8 grenades in MOUT training. The HC grenades are ignited and occasionally thrown into enclosed spaces. Soldiers enter the smoke-filled spaces to search for enemy forces. The frequency of exposure is medium [2]. Duration varies and is estimated to be medium [2]. The exposure concentration is high [3] if the person is in the cloud, especially in enclosed spaces. The total score of infantry soldiers exposed to HC smoke is 8.

(3) Other training activities involving HC smoke, such as EIB, EFMB, firefighter training, do occur randomly. The frequency is low [1]. The duration is minimal [1]. The exposure concentration is probably medium [2]. The total score of other personnel exposure to HC is 4.

c. Colored smoke. A principal use of colored smoke is for marking landing zones in air mobile operations. Other uses mentioned include distress signaling, signaling for prearranged coordinated military activities, search and rescue operations, and substitutes for HC smoke grenade. Colored smoke grenades are available in red, green, yellow, and violet. These colored smoke may be used singly or in combination with one another and with HC smoke. Colored smoke is favored because of the visual effects that smoke can produce. Any of the colored smokes may be used by the infantry, armored, air cavalry, air defense artillery, and combat engineers in various maneuvers such as hasty and deliberate attack, delay and defense, reaction to attack, movement to contact, mine defense, rear area security establishment, river crossing, area security, and target engagement.

(1) The frequency of personnel exposure to colored smoke in air mobile operations is low [1]. Duration is short [1]. The concentration levels to which personnel can be exposed depend on the wind direction and the on-ground movement of the personnel. Generally, the concentration is considered low [1]. The total score of air mobile operation personnel exposure to colored smoke is 3.

(2) The substitution of HC smoke with colored smoke often takes place in MOUT training, and the exposure of personnel to colored smoke can be intense. Otherwise, personnel exposure to colored smoke is most likely incidental. The frequency of personnel exposure to colored smoke is medium [2]. The duration also is estimated to be medium [2]. The exposure concentration is high [3] if exposure occurs. The total score for infantry soldiers' exposure to colored smoke is 8.

(3) In ARTEP training, colored smoke grenades are used in various maneuvers besides MOUT. If colored smoke is used, about four to sixteen grenades are expended during each training event. These numbers of grenades may be issued per company or even battalion basis. The frequency of training is considered to be medium to low [2]. The duration is short [1]. The exposure concentration is considered to be low [1]. The total score of the exposure severity for ARTEP training and similar activities is 4.

d. Diesel smoke is produced from the Vehicle Engine Exhaust Smoke System (VEESS). The VEESS is mounted on the rear of an armored vehicle, such as tanks, and Bradley fighting vehicles. The VEESS provides a self-protection screen for the armored vehicle, and was designed to be used no more than 15 minutes at a time. Smoke production usually occurs when the armored vehicle is in motion. Personnel are in the crew compartment of the armored vehicle. The VEESS is used to develop a smoke screen for various maneuvers in attempt to disengage from the enemy. In the process of retreat in a vehicle, soldiers will be inside the vehicles. There has not been information from the field about the use of diesel fuel/VEESS in routine training.

The frequency of diesel smoke use is low [1]. The duration of exposure to diesel smoke is expected to be low [1]. The expected exposure concentration levels for troop exposure is medium [2]. The total score is 4.

e. The M76 (Brass) armored vehicle-launched grenades containing brass materials are fired in salvos of three to six or two to four, depending on the type of grenade system. All armored vehicles are equipped with the salvos mounted on the gun turrets. The duration of the brass aerosol cloud is approximately 45 seconds. Armored vehicles may be equipped with a 50/50 mix of M76 and L8 grenades. Smoke is formed roughly 30 meters from the launching device. As the M76 grenades are fired, the vehicle may move behind the smoke screen. There exists a possibility that the vehicle may move through the cloud. The rate of the cloud dissipation outdoors is dependent upon the wind speed. If the vehicle is stationary, the smoke cloud may be driven by the wind towards the vehicle. Brass aerosol smoke may enter the crew compartment. The dissipation of brass smoke in the crew compartment depends on the efficiency of the vehicle's mechanical ventilation. There is insufficient information from the field regarding the use of M76 grenades.

The frequency of use is considered to be low [1]. The duration is short, i.e., 45 seconds [1]. The concentration may be high if the smoke enters the crew compartment. For this reason, a rating of 3 is given. The total score for brass is 5.

f. Phosphorus smoke is available in artillery and mortar rounds. These rounds are specifically used for projecting smoke on the enemy. In training, the phosphorus rounds are fired onto the impact zones; hence, troop exposure to phosphorus smoke would probably be minimal. Phosphorus smoke also can be delivered in the L8 armored vehicle launched grenade similar to the M76 and may be used with the M76.

The major concern with the use of L8 grenade is similar to the M76 exposure condition described above (paragraph 2e). The total score for the L8 phosphorus is therefore 5.

## APPENDIX E

### TOXICITY RANKING

Military exposures to obscurants/smokes occur mainly by inhalation and skin contact. Only the effects of exposure by these routes are considered in the toxicity rating. Smokes are rated as follows:

<u>Rating</u>	<u>Characteristics</u>
1	Practically harmless
2	Mild toxicity
3	Moderate toxicity
4	Severe toxicity
5	Acute exposure may produce fatalities

#### Fog oil

Repeated contact with fog oil can cause dermatitis. Repeated inhalation exposures to levels above 5 mg/m<sup>3</sup> can cause pulmonary granulomas. Fog oil purchased after April 1986 is not carcinogenic and should not be mutagenic. Toxicity rating = 2 + 0.

#### Diesel oil

Contact with diesel oil can irritate the skin. Repeated skin contact can cause severe skin irritation, weight loss, lack of appetite and depression. Aspiration of diesel fuel can cause chemical pneumonitis. Repeated inhalation can cause pulmonary inflammation and edema. Diesel fuel has been positive in some mutagenicity tests; results of cancer bioassays are equivocal. Toxicity rating = 4 + 0.5

#### Hexachloroethane

Exposure to high concentrations of HC smoke can cause severe skin irritation. Relatively low concentrations of HC smoke can be fatal (death is from lung congestion and pulmonary edema). Chronic exposure to HC smoke may cause cancer. Toxicity rating = 5 + 1

#### Phosphorous

Phosphorous smokes can irritate the eyes, nose, and throat. Short exposures to levels higher than 600 mg/m<sup>3</sup> can cause coughing, nasal discharge, and respiratory distress. Relatively low concentrations of phosphorous smoke can be fatal (death is from lung congestion and pulmonary edema). Phosphorous smokes are not known to contain carcinogens or teratogens. Toxicity rating = 5 + 0

## Brass

Brass particles are cleared rapidly from the lung. They are nonirritating to skin but can cause mild eye irritation. Repeated exposures to low concentrations (10 or 40 mg/m<sup>3</sup> for 4 weeks) can produce deficits in pulmonary function.

Toxicity rating = 3 + 0

## Colored Smokes

Old red dye: Exposure to this smoke can irritate the skin and eyes. It is a sensitizer and is a positive mutagen and animal carcinogen.

Toxicity rating = 2 + 1

Old yellow dye: This smoke is an eye irritant. Contact with the skin can cause itching, burning sensation, erythema, dermatitis, and pigmentation of skin. Exposure causes cancer in animals.

Toxicity rating = 3 + 1

Old green dye: This smoke is nonirritating but it causes cancer in animals.

Toxicity rating = 1 + 1

Old violet dye: This smoke is a moderate eye irritant and a positive mutagen.

Toxicity rating = 1 + 0.5

New yellow dye: This smoke is not irritating to skin or eyes. Repeated exposure (4 weeks) causes a mild inflammatory response in the respiratory tract with changes in pulmonary function. It is mutagenic.

Toxicity rating = 3 + 0.5

New green dye: Reports of eye irritation are conflicting. It causes a greater inflammatory response in the lung than does the yellow dye (i.e., its NOEL is one-tenth that of the new yellow dye). It is mutagenic.

Toxicity rating = 4 + 0.5

Proposed red dye: Toxicity studies with this dye are still in progress and the risks of exposure cannot yet be assessed. Preliminary evidence indicate that this dye is much less toxic than the proposed violet dye. Both components of this dye have recently been shown to be mutagenic.

Toxicity rating = ?? + 1

Proposed violet dye: This smoke is an eye irritant. Single exposures to concentrations greater than 300 mg/m<sup>3</sup> were lethal to rats and five daily exposures to 40 mg/m<sup>3</sup> caused severe liver and nasal lesions. This dye is mutagenic. This dye is no longer being considered for use in smokes.

Toxicity rating = 5 + 0.5

## APPENDIX F

### PRIORITY RANKING FOR EXPOSURE STUDIES

	<u>Exposure</u>	<u>Toxicity</u>	<u>Ranking</u>
1. Fog oil smoke			
a. Generator operators	8	2	16
b. Troops under smoke	7	2	14
2. Hexachloroethane			
a. Chemical school	1	6(5+1)	6
b. MOUT training	8	6(5+1)	48
c. Other training	4	6(5+1)	24
3. Colored smoke			
a. Air mobile operations	3	1.5-4.5 <sup>a</sup>	4.5-13.5
b. MOUT training	8	1.5-4.5	12-36
c. ARTEP training	4	1.5-4.5	6-17
4. Vehicle Engine Exhaust System - armored vehicle crewmen	4	4.5(4.0+0.5)	17
5. M76 IR Smoke Grenade - armored vehicle crewmen	5	3	15
6. L8 Red Phosphorus Grenade - armored vehicle crewmen	5	5	25

a. Depending on the dye used, toxicity and mutagenicity values will vary.  
See Appendix E.



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